

filament (fig. 175, *f*), and a broader portion, usually of two lobes, termed the *anther* (fig. 175, *a*), containing a powdery matter, called *pollen* (*p*), and supported upon the end of the filament. That portion of the filament in contact with the anther lobes is termed the *connective*. The exact morphological relations of these parts is not definitely settled. Some consider the filament as representing the petiole, and the anther as being the folded lamina; others again regard the connective as representing the lamina, the rest of the filament being the petiole, and the anther lobes as mere appendages of the lamina. The filament is no more essential to the stamen than the petiole is to the leaf, or the claw to the petal. If the anther is absent the stamen is abortive, and cannot perform its functions. The anther is developed before the filament, and when the latter is not produced, the anther is sessile, or has no stalk, as in the Mistletoe.

The *filament*, when structurally considered, is found to consist of a thin epidermis, on which occasionally stomata and hairs occur, and a layer of cellular tissue enclosing a bundle of spiral vessels, which traverses its whole length, and terminates at the junction between the filament and the anther. The filaments of *Callitriche verna* are said to have no vessels. The filament is usually, as its name imports, filiform or thread-like, cylindrical, or slightly tapering towards its summit. It is often, however, thickened, compressed, and flattened in various ways, becoming *petaloid* in *Canna*, *Maranta*, *Nymphaea alba* (fig. 179); *subulate* or slightly broadened at the base, and drawn out into a point like an awl, as in *Butomus umbellatus*; *davate*, that is, narrow below and broad above, as in *Thalictrum*. In some instances, as in *Tamarix gallica*, *Peganum Harmala*, and *Campanula*, the base of the filament is much dilated, and ends suddenly in a narrow thread-like portion. In these cases the base may represent the sheath or vagina of the leaf, and may give off stipular processes in a lateral direction, as in *Allium* and *Alyssum calycinum*. The filament varies much in length and in firmness. The length sometimes bears a relation to that of the pistil, and to the position of the flower, whether erect or drooping. The filament is usually of sufficient solidity to support the anther in an erect position; but sometimes, as in Grasses, it is very delicate and capillary, or hair-like, so that the anther is pendulous (fig. 212, *s*). The filament is generally continuous from one end to the other, but in some cases it is bent or jointed, becoming *geniculate*; at other times, as in the Pellitory, it is spiral. It is frequently colourless; but, in many instances, it exhibits different colours. In *Fuchsia* and *Poinciana*, it is red; in *Adamia* and *Tradescantia virginica*, blue; in *Oenothera* and *Ranunculus acris*, yellow.

Hairs, scales, teeth, or processes of different kinds are sometimes developed on the filament. In *Tradescantia virginica*, or *Spiderwort*, the hairs are beautifully coloured, moniliform or necklace-like, and *rotation* is seen in them (p. 84). Such a filament is bearded or *stipose*. At the base of the filament glandular or scaly appendages are occasionally produced, either on its internal or its external surface. These may be either parts of a whorl, to be afterwards noticed under the name of the disk, or separate prolongations from the filament itself, which is hence called *appendiculate*, or sometimes *strumose*. Filaments are usually articulated to the thalamus or torus, and the stamens fall off after fertilization; but in *Campanula* and some other plants they are continuous with the torus, and the stamens remain persistent, although in a withered state. Changes are produced in the whorl of stamens by cohesion of the filaments to a greater or less extent, while the anthers remain free; thus, all the filaments of the androecium may unite forming a tube round the pistil, or a central bundle

when the pistil is abortive, the stamens becoming *monadelphous*, as occurs in plants of the Mallow tribe; or they may be arranged in two bundles, the stamens being *diadelphous*, as in *Polygala*, *Fumaria*, and *Pea*; in this case the bundles may be equal or unequal. It frequently happens, especially in Papilionaceous flowers, that out of ten stamens nine are united by their filaments, while one (the posterior one) is free (fig. 218). When there are three or more bundles the stamens are *triadelphous*, as in *Hypericum ægyptiacum*, or *polyadelphous*, as in *Luhea paniculata* and *Ricinus communis*. In some cases, especially in the Mallow tribe, the stamens cohere, having been originally separate, but in most other cases each bundle is produced by the branching of a single stamen. When there are three stamens in a bundle we may conceive the lateral ones as of a stipular nature. In *Lauraceæ* there are perfect stamens, each having at the base of the filament two abortive stamens or staminodes, which may be analogous to stipules. Filaments sometimes are adherent to the pistil, forming a *columna* or column, as in *Stylidium*, *Asclepiadaceæ*, *Rafflesia*, *Orchidaceæ*, and *Aristolochiaceæ* (fig. 217). The column is called *gynostemium*, and the flowers are denominated *gynandrous*.

The *anther* consists of lobes containing minute powdery matter, called *pollen*, which, when mature, is discharged by a fissure or opening of some sort. The anther-lobes are considered by some as formed by the two halves of the lamina, their back corresponding to the under surface, and their face to the upper surface, united by the midrib, the pollen being the cellular tissue, and the fissure of the anther taking place at the margin, which, however, is often turned towards the face. In this view, the two cavities which are found to exist in each lobe may correspond with the upper and under layer of cells, separated by a septum equivalent to the fibro-vascular layer of the leaf. Others view the anther as formed by each half of the lamina being folded upon itself, so that the outer surface of both face and back corresponds to the lower side of the leaf, and the septum dividing each cavity into two is formed by the united upper surfaces of the folded half. Again, others hold that the connective represents the lamina of the leaf to which the anther lobes are mere appendages. There is a double covering of the anther—the outer, or *exothecium*, resembles the epidermis, and often presents stomata and projections of different kinds (fig. 219); the inner, or *endothecium*, is

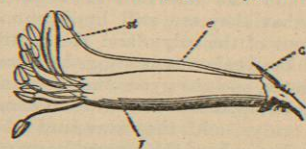


Fig. 218.



Fig. 219.

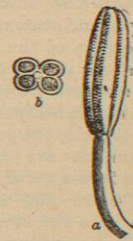


Fig. 220.

Fig. 218.—Stamens and pistil of Sweet Pea (*Lathyrus*). The stamens are diadelphous, nine of them being united by their filaments *f* while one of them, *t*, is free; the upper part of the pistil is marked *u*, the calyx, *c*.
Fig. 219.—Broken-down fibrous cells *cf* of the endothecium of the anther of the Melon. The walls of the cells are absorbed, and the fibres are set free. The exothecium or outer epidermis is marked *ex*.
Fig. 220.—Quadrilocular or tetralocular anther of the flowering Rush (*Butomus umbellatus*). The anther entire, *a*, with its filament; section of anther, *b*, showing the four loculi.

formed by a layer or layers of cellular tissue (fig. 219, *cf*), the cells of which have a spiral, annular, or reticulated fibre in their interior. This internal lining varies in thickness,

generally becoming thinner towards the part where the anther opens, and there disappears entirely. The walls of the cells are frequently absorbed, so that when the anther attains maturity the fibres are alone left, and these by their elasticity assist in discharging the pollen. The anther is developed before the filament, and is always sessile in the first instance, and sometimes continues so. It appears at first as a simple cellular papilla of meristem, upon which an indication of two lobes soon appears. Upon these projections the rudiments of the pollen-sacs are then seen, usually four in number, two on each lobe. In each a differentiation takes place in the layers beneath the epidermis, by which an outer layer of small-celled tissue surrounds an inner portion of large cells. Those central cells are the mother-cells of the pollen, whilst the small-celled layer of tissue external to them becomes the endothecium, the exothecium being formed from the epidermal layer.

In the young state there are usually four pollen-sacs or cavities produced, two for each anther-lobe, and when these remain permanently complete, it is a *quadrilocular* or *tetralocular* anther (fig. 220). The four cavities are sometimes placed in apposition, as in *Poranthera*, and *Tetratea juncea*, and at other times two are placed above and two below, as in *Persea gratissima*. Sometimes, however, only two cavities remain in the anther, by union of the sacs in each lobe, in which case the anther is said to be *bilocular* or *dithecal*. Sometimes the anther has a single cavity, and becomes *unilocular*, or *monothechal*, or *dimidiate*, either by the disappearance of the partition between the two lobes, or by the abortion of one of its lobes, as in *Styphelia læta* and *Althæa officinalis*. Occasionally there are numerous cavities in the anther, as in *Viscum* and *Rafflesia*. The form of the anther-lobes varies. They are generally of a more or less oval or elliptical form, or they may be globular, as in *Mercurialis annua*; at other times linear or clavate, curved, flexuose, or sinuose or *anfractuose*, as in *Bryonia* and *Gourd*. According to the amount of union of the lobes and the unequal development of different parts of their surface an infinite variety of forms are produced. That part of the anther to which the filament is attached, and which is generally towards the petals, is the *back*, the opposite being the *face*. The division between the lobes is marked on the face of the anther by a groove or *furrow*, and there is usually on the face a *suture*, indicating the line where the membranous coverings open to discharge the pollen. The suture is often towards one side in consequence of the valves being unequal. The stamens may cohere by their anthers, and become *syngenesious* or *synantherous*, as in Composite flowers, and in *Lobelia*, *Jasione*, *Viola*, &c.

The anther-lobes are united to the *connective*, which may be either continuous with the filament or articulated with it. It consists of parenchyma, in which the spiral vessels of the filament terminate. From the connective a partition or *septum* extends across each antherine loculus, dividing it either partially or completely. The septum sometimes reaches the suture. When the filament is continuous with the connective, and is prolonged so that the anther-lobes appear to be united to it throughout their whole length, and lie in apposition to it and on both sides of it, the anther is said to be *adnate* or *adherent*; when the filament ends at the base of the anther, then the latter is *innate* or *erect*. In these cases the anther is to a greater or less degree fixed. When, however, the attachment is very narrow, and an articulation exists, the anthers are movable, and are easily turned by the wind. This is well seen in what are called *versatile* anthers, as in *Tritonia*, Grasses, &c. (fig. 212), where the filament is attached only to the middle of the connective; and it may occur also in cases where it is attached to the apex, as in pendulous

anthers. The connective may unite the anther-lobes completely, or only partially. It is sometimes very short, and is reduced to a mere point, so that the lobes are separate or free. At other times it is prolonged upwards beyond the lobes, assuming various forms, as in *Acalypha*, and *Nerium Oleander*; or it is extended backwards and downwards, as in *Violet* (fig. 221), and *Ticorea febrifuga*. In *Salvia officinalis* the connective is attached to the filament in a horizontal manner, so as to separate the two anther-lobes, and then it is called *distractile* (fig. 222); one of the lobes only being perfect or fertile, containing pollen, the other imperfectly developed and sterile. In *Stachys* the connective is expanded laterally, so as to unite the bases of the antherine lobes, and bring them into a horizontal line.

The opening of the anthers to discharge their contents is denominated *dehiscence*. This takes place either by clefts, by hinges, or by pores. When the anther-lobes are erect, the cleft takes place lengthwise along the line of the suture, constituting *longitudinal dehiscence* (fig. 175). At other times the slit takes place in a horizontal manner, from the connective to the side, as in *Alchemilla arvensis* (fig. 223) and in *Lemna*; the dehiscence is then *transverse*. When the anther-lobes are rendered horizontal by the enlargement of the connective, then what is really longitudinal dehiscence may appear to be transverse. In other cases, when the lobes are united at the base, the fissure in each of them may be continuous, and the two lobes may appear as one. The cleft does not always proceed the whole length of the anther-lobe at once, but often for a time it extends only partially. In other instances the opening is confined to the base or apex, each loculament opening by a single pore, as in *Pyrola*, *Tetratea juncea*, *Rhododendron*, *Vaccinium*, and *Solanum* (fig. 224), where there are

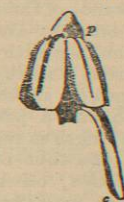


Fig. 221.



Fig. 223.



Fig. 224.

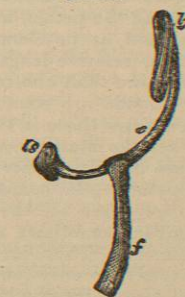


Fig. 222.



Fig. 225.

Fig. 221.—Two stamens of Pansy (*Viola tricolor*), with their two anther lobes and the process *p* extending beyond them. One of the stamens has been deprived of its spur, the other shows its spur, *c*.
Fig. 222.—Anther of *Salvia officinalis*. *lf*, fertile lobe full of pollen; *ls*, barren lobe without pollen; *c*, distractile connective; *f*, filament.
Fig. 223.—Stamen of Lady's Mantle (*Alchemilla*), with the anther opening transversely.
Fig. 224.—Stamen of a species of Nightshade (*Solanum*), showing the divergence of the anther-lobes at the base, and the dehiscence by pores at the apex *a*.
Fig. 225.—The stamen of the Barberry (*Berberis vulgaris*), showing one of the valves of the anther *v*, curved upwards, bearing the pollen on its inner surface.

two, and *Poranthera*, where there are four; whilst in the Mistletoe the anther has numerous pores for the discharge of the pollen. Another mode of dehiscence is called

hinged. In the Barberry (fig. 225) each lobe opens by a valve on the outer side of the suture, separately rolling up from base to apex; in some of the Laurel tribe there are two such valves for each lobe, or four in all. This may be called a combination of transverse and hinged dehiscence. In some Guttiferae, as *Hebradendron cambogioides* (the Ceylon Gamboge plant), the anther opens by a lid separating from the apex; this is called *circumscissile* dehiscence.

The anthers dehiscence at different periods during the process of flowering; sometimes in the bud, but more commonly when the pistil is fully developed, and the flower is expanded. They either dehiscence simultaneously or in succession. In the latter case individual stamens may move in succession towards the pistil and discharge their contents, as in *Parnassia palustris*, or the outer or the inner stamens may first dehiscence, following thus a centripetal or centrifugal order. The anthers are called *introrse* or *antice*, when they dehiscence by the surface next to the centre of the flower; they are *extrorse*, or *postice*, when they dehiscence by the outer surface; when they dehiscence by the sides, as in *Iris* and some grasses, they are *laterally* dehiscence. Sometimes, from their versatile nature, anthers originally introrse become extrorse, as in the Passion-flower and Oxalis.

The usual colour of anthers is yellow, but they present a great variety in this respect. They are red in the Peach, dark purple in the Poppy and Tulip, orange in *Eschscholtzia*, &c. The colour and appearance of the anthers often change after they have discharged their functions.

Stamens occasionally become sterile by the degeneration or non-development of the anthers. Such stamens receive the name of *staminodia*, or rudimentary stamens. In *Scrophularia* the fifth stamen appears in the form of a scale; and in many Pentstemons it is reduced to a filament with hairs or a shrivelled membrane at the apex. In other cases, as in double flowers, the stamens are converted into petals; this is also probably the case with such plants as *Mesembryanthemum*, where there is a multiplication of petals in several rows. Sometimes, as in *Canna*, one of the anther-lobes becomes abortive, and a petaloid appendage is produced. Stamens vary in length as regards the corolla. Some are enclosed within the tube of the flower, as in *Cinchona*, and are called *included*; others are *exserted*, or extend beyond the flower, as in *Littorella*, *Plantago*, and *Exostemma*. Sometimes the stamens in the early state of the flower project beyond the petals, and in the progress of growth become included, as in *Geranium striatum*. Stamens also vary in their relative lengths as respects each other. When there is more than one row or whorl in a flower, those on the outside are sometimes longest, as in many Rosaceae; at other times those in the interior are longest, as in *Luhea*. When the stamens are in two rows, those opposite the petals are usually shorter than those which alternate with the petals. It sometimes happens that a single stamen is longer than all the rest. A definite relation, as regards number, sometimes exists between the long and the short stamens. Thus, in some flowers the stamens are *didynamous*, having only four out of five stamens developed, and the two corresponding to the upper part of the flower longer than the two lateral ones. This occurs in Labiate and Scrophulariaceae (fig. 226). Again, in other cases, there are six stamens, whereof four long ones are arranged in pairs opposite to each other, and alternate with two isolated short ones (fig. 227), giving rise to *tetradynamous* flowers, as in Cruciferae. Stamens, as regards their direction, may be erect, turned inwards, outwards, or to one side. In the last-mentioned case they are called *declinate*, as in *Amaryllis*, *Horse-chestnut*, and *Fraxinella*.

The pollen or powdery matter contained in the anther

consists of small cells developed in the interior of other pollen cells. These are produced in the large thick-walled mother-

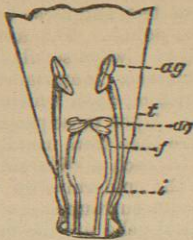


Fig. 226.

Fig. 226.—Corolla of *Digitalis purpurea*, cut in order to show the didynamous stamens (two long and two short) which are attached to it. *t*, tube; *f*, filaments which are united to the corolla at *t*, and run along its inner surface, having formed a marked adhesion; *ag*, anthers of the long stamens; *aq*, anthers of the short stamens.



Fig. 227.

Fig. 227.—Tetradynamous stamens (four long and two short) of *Cheiranthus Cheiri*. *p*, top of the peduncle; *c*, cicatrices left by the sepals of calyx which have been removed; *ep*, two pairs of long stamens; *ep* the short stamens; *t*, torus or thalamus to which the stamens are attached.

cells or pollen utricles, formed in the interior of the pollen-sacs of the young anther. These mother-cells are either separated from one another and float in the granular fluid which fills up the cavity of the pollen-sac, or are not so isolated. A division takes place, by which four cells are formed in each, the exact mode of division differing in Dicotyledons and Monocotyledons. These cells are the pollen-cells or grains. They increase in size and acquire a cell-wall, which becomes differentiated into an outer cuticular layer, or *extine*, and an inner layer, or *intine*. Then the walls of the mother-cells are absorbed, and the pollen-grains float freely in the fluid of the pollen-sacs, which gradually disappears, and the mature grains form a powdery mass within the anther. They then either remain united in fours, or multiples of four, as in some Acacias, *Periploca græca*, and *Inga anomala*, or separate into individual grains, which by degrees become mature pollen. Occasionally the membrane of the pollen-cell is not completely absorbed, and traces of it are detected in a viscous matter surrounding the pollen-grains, as in Onagraceae. In Orchidaceous plants the pollen-grains are united into masses, or *pollinia* (fig. 228), by means of viscid matter.

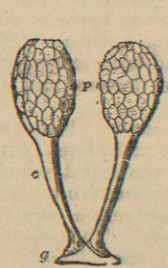


Fig. 228.

Fig. 228.—Pollinia, or pollen-masses, separated from the point above the stigma, with their retinacula or viscid matter attaching them at the base. The pollen masses *p* are supported on stalks or caudicles *c*. These masses are easily detached by the agency of insects.



Fig. 229.

Fig. 229.—Pistil of *Asclepias*, *a*, with pollen-masses, *p*, adhering to the stigma. *b*, pollen-masses, removed from the stigma, united by a gland-like body.



Fig. 230.

In Orchids each of the pollen-masses has a prolongation or stalk, called a *caudicle*, which adheres to a prolongation at the base of the anther, called *rostellum*, by means of a viscid gland, called *retinaculum*. The gland is either naked or covered. The term *clinandrium* is sometimes applied to the part of the column in Orchids where the

stamens are situated. In some Orchids, as *Cypripedium*, the pollen has its ordinary character of separate grains. The number of pollinia varies; thus, in Orchis there are usually two, in *Cattleya* four, and in *Lælia* eight. The two pollinia in *Orchis Morio* contain each about 200 secondary smaller masses. These small masses, when bruised, divide into grains which are united in fours. In Asclepiadaceae the pollinia are usually united in pairs (fig. 229), belonging to two contiguous antherine cavities,—each pollen-mass having a caudicular appendage, ending in a common gland, by means of which they are attached to a process of the stigma. The pollinia are also provided with an appendicular staminal covering (fig. 230).

When mature, the pollen-grain is a cellular body having an external covering, *extine*, and an internal, *intine*. Fritzsche states that he has detected, in some cases, other two coverings, which he calls *intextine* and *exintine*. They occur between the extine and intine, and are probably formed by foldings of these membranes. In some aquatics, as *Zostera marina*, *Zannichellia pedunculata*, *Naias minor*, &c., only one covering exists, and that is said to be the *intine*. The extine is a firm membrane, which defines the figure of the pollen-grain, and gives colour to it. It is either smooth, or covered with numerous projections (fig. 231), granules, points, minute hairs, or crested reticulations. The colour is generally yellow, and the surface is often covered with a viscid or oily matter. The intine is uniform in different kinds of pollen, thin and transparent, and possesses great power of extension.

Pollen-grains vary from $\frac{1}{300}$ to $\frac{1}{100}$ of an inch or less in diameter. Their forms are various. The most common form of grain is ellipsoidal, more or less narrow at the extremities, which are called its *poles*, in contradistinction to a line equidistant from the extremities, and which is its equator. Pollen-grains are also spherical; cylindrical and curved, as in *Tradescantia virginica*; polyhedral in *Dipsacaceae* and *Compositae*; nearly triangular in *Proteaceae* and *Onagraceae* (fig. 232). The surface of the pollen-grain is either uniform and homogeneous, or it is marked by



Fig. 231.



Fig. 232.



Fig. 233.

Fig. 231.—Ripe round pollen of *Hollyhock (Althæa)*, with its extine covered with prominent points.

Fig. 232.—Triangular pollen of *Evening Primrose (Oenothera)*, with one pollen tube, *t*, protruded. This tube is formed by the intine, which is also seen projecting at the other angles.

Fig. 233.—Ripe rounded pollen of *Cherry (Cerasus)*, discharging its fovilla through a tubular opening formed by the intine. There are other two points at which the intine is seen protruding.

Fig. 234.—Male flower of *Pellitory (Parietaria officinalis)*, having four stamens with incurved elastic filaments, and an abortive pistil in the centre. When the petals expand, the filaments are thrown out with force, so as to scatter the pollen on the female flowers in the vicinity.

folds dipping in towards the centre, and formed by thinnings of the membrane. In Monocotyledonous plants there

is usually a single fold; in Dicotyledons, often three. Two, four, six, and even twelve folds are also met with. There are also rounded portions of the membrane or points of perforation or pores visible in the pollen-grain. These vary in number from one to fifty. In Monocotyledons, as in Grasses, there is often only one, while in Dicotyledons they number from three upwards. When numerous, these points are either scattered irregularly, or in a regular order, frequently forming a circle round the equatorial surface. Sometimes at the place where they exist, the outer membrane, in place of being thin and transparent, is separated in the form of a lid, thus becoming *operculate*, as in the *Passion-flower* and *Gourd*. Grains of pollen have sometimes both folds and pores. Within the pollen-grain a granular semifluid matter called *fovilla* is contained, along with some oily particles, and occasionally starch. The fovilla contains small spherical granules, sometimes the $\frac{1}{3000}$ of an inch in diameter, and large ellipsoidal or elongated corpuscles, which exhibit molecular movements under the microscope. The application of moisture affects very markedly the pollen-grain, causing it to swell up by endosmose. If the moisture be long applied the distension becomes so great as to rupture the extine irregularly if it is homogeneous, or to cause projections and final rupture at the folds or pores when they exist. The intine, from its distensibility, is not so liable to rupture; it is often forced through the ruptured extine, or through the pores, in the form of small sac-like projections. The internal membrane ultimately gives way, and allows the granular fovilla to escape (fig. 233). If the fluid is applied only to one side of the pollen-grain, as when the pollen is applied to the pistil, the distension goes on more slowly, and the intine is prolonged outwards like a hernia, and forms an elongated tube called a *pollen-tube* (fig. 232). This tube, at its base, is often covered by the ruptured extine, and it contains in its interior fovilla-granules. The number of pollen-tubes which may be produced depends on the number of pores. In some pollinia the number of tubes which are formed is enormous. Thus, it has been calculated that two pollen-masses of *Orchis Morio* may give out 120,000 tubes.

When the pollen-grains are ripe, the anther dehiscence (figs. 175, 223), and the pollen is shed. In order that fertilization may be effected the pollen must be conveyed to the female organ of reproduction. This process, termed *pollination*, is promoted in various ways,—the whole form and structure of the flower having relation to the process. In some plants, as *Kalmia* and *Pellitory* (fig. 234), the mere elasticity of the filaments is sufficient to effect this; in other plants pollination is effected by the wind, as in *Coniferae*, and in such cases enormous quantities of pollen are produced. These plants are *anemophilous*. But the common agents for pollination are insects. To allure and attract them to visit the flower the odoriferous secretions and gay colours are developed, and the position and complicated structure of the parts of the flower are adapted to the perfect performance of the process. It is rare in hermaphrodite flowers for self-fertilization to occur, and the various forms of dichogamy, dimorphism, and trimorphism are fitted to prevent this.

Under the term *disk* is included every structure intervening between the stamens and the pistil. It was to such structures that the name of *nectary* was applied by old authors. It presents great varieties of form, such as a ring, scales, glands, hairs, petaloid appendages, &c., and in the progress of growth it often contains saccharine matter, thus becoming truly nectariferous. The disk is frequently formed by degeneration or transformation of the staminal row. It may consist of processes rising from the torus, alternating with the stamens, and thus representing an abortive whorl; or its parts may be oppo-

site to the stamens, as in *Crassula rubens* (fig. 172). In some flowers, as *Jatropha Curcas*, in which the stamens are not developed, their place is occupied by glandular bodies forming the disk. In Gesneraceae and Cruciferae the disk consists of tooth-like scales at the base of the stamens (fig. 227). The parts composing the disk sometimes unite and form a glandular ring, as in the Orange; or they form a dark-red lamina covering the pistil, as in *Paeonia Moutan* (fig. 235); or a waxy lining of the calyx tube or hollow receptacle, as in the Rose; or a swelling at the top of the ovary, as in Umbelliferae, in which the disk is said to be epigynous. The enlarged torus covering the ovary in *Nymphaea* and *Nelumbium* may be regarded as a form of disk.

2. Male Organs in Cryptogams.

Sexual organs have not as yet been demonstrated in all Cryptogamic plants; but in most of them certain structures representing the male organs have been found. These are termed *Antheridia* or *Pollinodia* (figs. 236, 250). They are closed sacs of various forms,—rounded, ovate, oblong, clavate, flask-like, &c.,—developed from various parts of the plants, and composed either of one or of many cells enclosing a single central cell. In the interior of this organ small cells (fig. 236, c) are formed of varying shape, containing in their interior peculiar bodies, termed *antherozoids*, *spermatozoids*, or *phytozoa* (fig. 237). These are in most cases filamentous spirally coiled cells, frequently with *cilia*

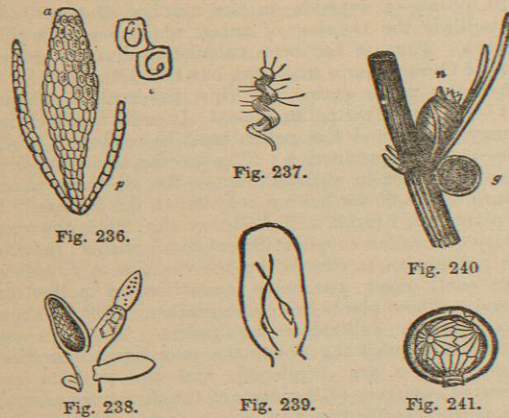


Fig. 236.—Antheridium *a* of the Hair-moss (*Polytrichum*), consisting of cells *e*, containing phytozoa coiled up in their interior. The phytozoa have a thickened extremity, whence proceeds a tapering tail-like process. Along with the antheridium are two separate filaments or paraphyses *p*, which are probably abortive antheridia.
 Fig. 237.—A spermatozoid with cilia, discharged from a cellule in the antheridium of the Forked Spleenwort (*Asplenium septentrionale*).
 Fig. 238.—Antheridium *a*, or zootheca, of a Sea-weed (*Fucus serratus*), containing phytozoa. With the antheridium there are paraphyses united in the same conceptacle.
 Fig. 239.—Antheridium of a Sea-weed (*Fucus serratus*), still containing two phytozoa in the sac. To the broad part of the phytozoa two vibratile cilia are attached.
 Fig. 240.—Axis of Chara, with branches from the axil of which arises the nucule *n*; below them is the globule *g*.
 Fig. 241.—Globule of Chara, being a rounded body with eight radiating valves externally, and filaments containing phytozoary cells internally.

attached, by means of which they move rapidly through the water. In some cases there are no cilia, as in the Algal group of Floridæ; and the antherozoids of all Alge differ

from those of other Cryptogams in never being filamentous, but short and more or less rounded. The amount of twisting of the antherozoid varies; in some Rhizocarps there are as many as a dozen coils. Antheridia of this kind have been demonstrated in all vascular Cryptogams, but only in some Thallogens have such structures been seen.

In Characeae, however, the antheridium, which is here termed *globule* (fig. 240), has a peculiar structure, differing from all other Cryptogams. It is a globular case, formed by eight flat cells, of which four are quadrangular and four are triangular; and these are folded at the margins so that the edges of contiguous plates dovetail (fig. 241). These are termed *shields*. Into the cavity of the globule the terminal cell of the stalk supporting it projects. From the centre of each shield projects on the inner surface a large oblong cell or *manubrium*, which in turn bears at its apex a roundish cell termed the *head*. From each head-cell six secondary head-cells project, from each of which pass off four slender separate filaments (fig. 242) containing antherozoids.

When mature the antheridium is ruptured, and the mother-cells of the antherozoid escape and discharge the antherozoids into the surrounding medium which is always water—fertilization only being effected in water, by which the antherozoids are carried to the female organ. In some cases, however, among Thallogens the antheridium actually penetrates into the female organ.

Antheridia are produced on various parts of plants. Where they have been found amongst Thallogens, they arise from definite portions of the cellular thallus. In thalloid Hepaticæ they may be sunk in the substance of the thallus, or they may be imbedded in the upper surface of a peltate stalked disk rising from the thallus, as in *Marchantia* (figs. 243, 244). In Mosses they may be seated within the same whorl of leaves or perichætium as the female organs, or they may be separate and surrounded by a *perigone*; but they are always formed upon the leaf-bearing axis, either terminal or lateral. In Ferns and Equisetum they are produced on the surface—usually the lower surface—of a cellular flattened expansion, termed a *prothallus* (figs. 245, 250), in close proximity to the female organs. In Characeae they always arise from the termination of one of the whorled leaflets.

In some Lycopodiaceae no antheridia have as yet been found; but in Selaginella, Isoetes, and in the Rhizocarpeae, hollow sacs, termed *microsporangia* (figs. 246, 248), are produced in the axil of certain leaves of the

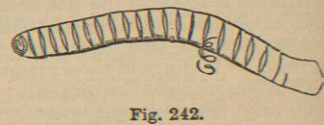


Fig. 242.—Partitioned filament of Chara, consisting of a series of cellules containing phytozoa, one of which is seen escaping in the form of a spiral thread.

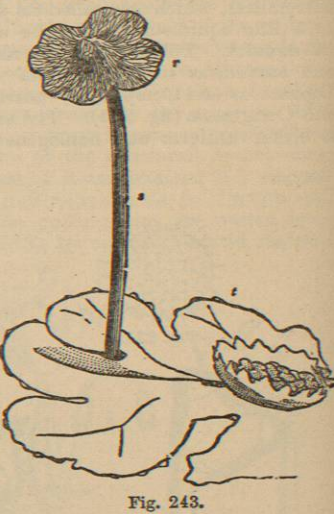


Fig. 243.—A species of Liverwort (*Marchantia polymorpha*) with its green thallus *t*, bearing a cup-like body *p*, in which minute cells or free buds are seen, and a stalked receptacle *r*. In the substance of the disk-like receptacle *r* cells are produced containing phytozoa. These are considered antheridia.

plant, in which small cells, *microspores* (fig. 249), are found, each consisting of an outer covering or *exospore*, and an inner or *endospore*. Within these microspores (the manner varying in different genera) smaller cells are formed, which are the mother-cells of the antherozoids. In this

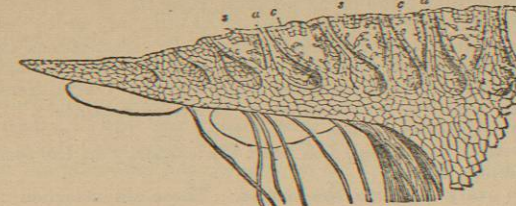


Fig. 244.

Vertical section of the disk-like receptacle of Liverwort (*Marchantia*), showing antheridia *a*, *a* in its substance. These antheridia are flask-shaped sacs containing phytozoary cells. They communicate with the upper surface, and their contents are discharged through it. Between the antheridia there are air cavities *c*, *c*, connected with stomata *s*, *s*.

development of Lycopodiaceae we have parts which are analogous to those of the stamens in Phanerogams. The microsporangium evidently corresponds to the pollen-sac, and the microspores are the equivalents of the pollen-grains,—the forms seen in such Gymnosperms as Cycadaceae being the link connecting them with the highest forms.

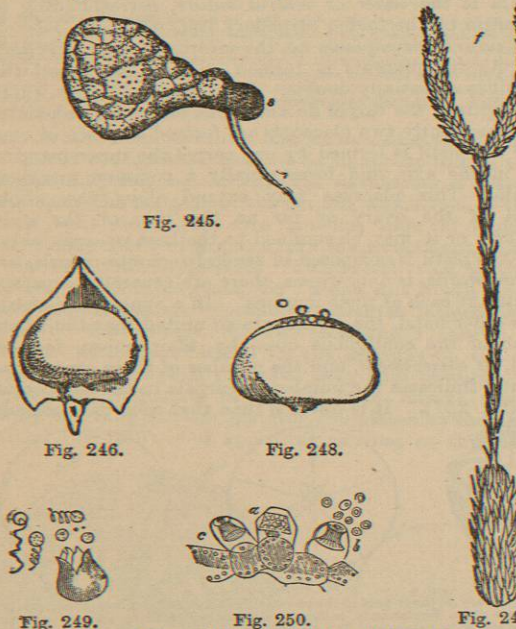


Fig. 245.—Spore *s*, of a Fern (*Pteris longifolia*) sprouting, giving off a root-like process, *r*, and a flat cellular expansion, *p*, called the prothallus or prothallium. On this expansion antheridia and pistillidia are said to occur.
 Fig. 246.—Fructification of Club-Moss (*Lycopodium*), situated in the axil of a leaf, *l*. It consists of a case containing minute cellular bodies, which are discharged in the form of powder.
 Fig. 247.—Fructification of a Club-Moss (*Lycopodium elatum*). The branch is covered with minute pointed leaves, *f*; from it proceeds a stalk bearing at its extremity two spikes, *f*, consisting of modified leaves, with fructification.
 Fig. 248.—One of the cases separated from the axil of the Club-Moss leaf, opening by two valves, and discharging the minute Lycopod powder (microspores).
 Fig. 249.—The small spore of a Rhizocarp (*Pilularia globulifera*, Pillwort). The inner coat is protruded, and the outer coat has burst so as to discharge cellules containing spermatozoids. Some of the spermatozoids are separate, and are seen coiled up in a spiral form.
 Fig. 250.—Antheridia from the prothallus of the Common Brake (*Pteris aquilina*). *a*, an unopened antheridium; *b*, antheridium bursting at the apex, and discharging free cellules, each containing a spermatozoid; *c*, antheridium after the discharge of the cellules.

3. Female Organs in Phanerogams.

The pistil or gynoecium occupies the centre or axis of the

flower, and is surrounded by the stamens and floral envelopes when these are present. It constitutes the innermost whorl, and is the female organ of the plant, which after flowering is changed into the fruit, and contains the seeds. It consists essentially of two parts, a basal portion forming a chamber, the *ovary* or *germen*, containing ovules or young seeds attached to a part called the *placenta*, and an upper portion, the *stigma*, a cellular secreting body, which is either seated on the ovary, and is then called *sessile*, as in the Tulip and Poppy, or is elevated on a stalk called the *style*, interposed between the ovary and stigma. The style

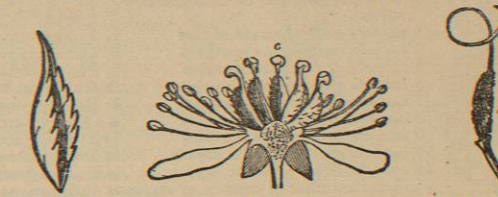


Fig. 251.—Folded carpellary leaf of the double-flowering Cherry. In place of fruit the plant produces leaves.
 Fig. 252.—Vertical section of the flower of Meadow-sweet (*Spiraea*). The pistil is apocarpous, consisting of several distinct carpels *c*, each with ovary, style, and stigma. The stamens are indefinite, and are inserted into the calyx.
 Fig. 253.—Pistil of Broom, consisting of ovary *o*, style *s*, and stigma *t*. It is formed by a single carpel. The terms pistil and carpel are here synonymous.

is not necessary for the perfection of the pistil. Like the other organs, the pistil consists of one or more modified leaves, which in this instance are called *carpels*. When a pistil consists of a single carpel it is *simple* or *monocarpellary* (fig. 253), a state usually depending on the non-development of other carpels. When it is composed of several carpels, more or less united, it is *compound* or *polycarpellary*. In the first-mentioned case the terms carpel and pistil are synonymous. Each carpel has its own ovary, style (when present), and stigma, and is formed by a folded leaf, the upper surface of which is turned inwards towards the axis, and the lower outwards, while from its margins are developed one or more buds called *ovules*. That this is the true nature of the pistil may be seen by examining the flower of the double-flowering Cherry. In it no fruit is produced, and the pistil consists of sessile leaves (fig. 251), the limb of each being green and folded, with a narrow prolongation upwards, as if from the midrib, and ending in a thickened portion. The ovary then represents the limb or lamina of the leaf, and is composed of cellular tissue with fibrovascular bundles, and an epidermal covering. The cellular tissue, or parenchyma, often becomes much developed, as will be seen particularly when fleshy fruits are considered. The outer epidermis corresponds to the lower side of the leaf, exhibiting stomata, and sometimes hairs; the inner surface represents the upper side of the leaf, being usually very delicate and pale, and forming a layer called sometimes *epithelium*, which does not exhibit stomata. The vascular bundles correspond with the veins of the leaf, and consist of spiral, annular, and other vessels. In Cycas the carpels are ordinary leaves, with ovules upon their margin.

A pistil is usually formed by more than one carpel. The carpels may be arranged like leaves, either at the same or nearly the same height in a verticil, or at different heights in a spiral cycle. When they remain separate and distinct, thus showing at once the composition of the pistil, as in *Caltha*, *Ranunculus*, *Hellebore*, and *Spiraea* (fig. 252), the term *apocarpous* is applied. Thus, in *Crassula rubens* (fig. 172) the pistil consists of five verticillate carpels *o*, alternating with the stamens *e*. In the Tulip-tree and *Ranunculus* (fig. 254) the separate carpels are numerous and are arranged in a spiral cycle upon an elongated axis or receptacle. In the Raspberry the carpels are on a conical